ORIGINAL ARTICLE

Occupational accidents aboard merchant ships

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Objectives: To investigate the frequency, circumstances, and causes of occupational accidents aboard merchant ships in international trade, and to identify risk factors for the occurrence of occupational accidents as well as dangerous working situations where possible preventive measures may be initiated.
Methods: The study is a historical follow up on occupational accidents among crew aboard Danish merchant ships in the period 1993–7. Data were extracted from the Danish Maritime Authority and insurance data. Exact data on time at risk were available.
Results: A total of 1993 accidents were identified during a total of 31 140 years at sea. Among these, 209 accidents resulted in permanent disability of 5% or more, and 27 were fatal. The mean risk of having an occupational accident was 6.4/100 years at sea and the risk of an accident causing a permanent disability of 5% or more was 0.67/100 years aboard. Relative risks for notified accidents and accidents causing permanent disability of 5% or more were calculated in a multivariate analysis including ship type, occupation, age, time on board, change of ship since last employment period, and nationality. Foreigners had a considerably lower recorded rate of accidents than Danish citizens. Age was a major risk factor for accidents causing permanent disability. Change of ship and the first period aboard a particular ship were identified as risk factors. Walking from one place to another aboard the ship caused serious accidents. The most serious accidents happened on deck.
Conclusions: It was possible to clearly identify work situations and specific risk factors for accidents aboard merchant ships. Most accidents happened while performing daily routine duties. Preventive measures should focus on workplace instructions for all important functions aboard and also on the prevention of accidents caused by walking around aboard the ship.

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Merchant shipping is known to be an occupation with a high rate of fatal accidents caused by maritime disasters and occupational accidents. Abell[1] and Verdier[2] analysed fatalities in the British fleet covering data from before the first world war. More recently, Larsson and Lindquist analysed Swedish fatalities,[3] Jaremin investigated Polish fatalities,[4] and Nielsen and Roberts attempted to establish worldwide fatality rates of merchant seafarers due to different causes.[5] Detailed information also exists for the Danish merchant fleet showing a more than 10 times higher rate of fatal accidents than in shore based industries.[6]

Despite some international concern about the problem,[7] few studies cover the aspect of non-fatal accidents on board cargo carrying ships. Seal *et al*[8] used patient records in a Bombay port clinic whereas Cramm *et al*[9] analysed data on patients in the Antwerp port health clinic. Fulvio *et al*[10] recently presented data compiled in the Radio Medical Centre in Rome, Italy, which gives advice to ship's masters in cases of illnesses or accidents at sea. Some crude statistics on non-fatal accidents are published by, for example, the United Kingdom, Sweden, or Germany, and some of these data have been summarised by the International Labour Organisation,[7] who also have taken some initiatives to improve safety aboard ships.[11] No data are available for the bigger fleets in the world—such as Panama or Liberia—although reporting of occupational accidents is mandatory in both states. Bermuda or Cyprus, so called open registers, have no reporting systems in place, and Malta is in the process of establishing a reporting system for fatal accidents (personal communications). The existing statistics indicate a high rate of fatal accidents but few in depth analyses of non-fatal accidents exist.[12]

The purpose of this study was to investigate the frequency, circumstances, and causes of occupational accidents aboard merchant ships in international trade. The first aim was to identify risk factors for the occurrence on accidents focusing on ship and job types, duration of stay aboard, nationality, age, and influence of change of ship between two employment periods. The second aim was to identify dangerous working situations where possible preventive measures may be initiated.

MATERIAL AND METHODS

This study is a historical follow up study on occupational accidents among crew aboard Danish merchant ships registered in the Danish international shipping registry in the period 1993–7. In practice all ships under the Danish flag in international trade are registered in the Danish international shipping registry. All legislation on safety standards, occupational health, and obligations to report accidents and insure crew members are the same in the international registry as for other ships under the Danish flag. The only important difference between the Danish international shipping registry and other ships is the taxation of the crew. In the year 1997 there were 502 ships registered in the Danish international shipping registry making up around 1.1% of the world's merchant fleet measured in tonnes dead weight.[13] Manning requirements in terms of number of crew are low compared with many other countries but safety standards are generally seen as high.

DATA SOURCES

Notified accidents

Data used in this study were extracted from three different, independent sources. Information on notified accidents has been obtained from a computerised registry run by the Danish Maritime Authority and the original notifications. In some cases, supplementary data sent to the authorities were available. The Danish Marine Accident Investigation Board has investigated all fatal accidents and some of the more serious notified accidents and their files were perused to compile

Table 1 Disability distribution among 209 cases causing 5% disability or more and examples of disability in each group (the examples are from the study cohort)

Disability (%)	Cases (n)	Percentage of total	Examples of type of disability
5	85	40.7	Chronic lumbar problems. Lost finger. Chronic knee problems. Dysfunction of wrist or hand.
8	51	24.4	Chronic lumbar and ankle problems. Incapacity of shoulder function. Slight brain damage.
10	22	10.5	Severe chronic lumbar problems. Severe incapacity of shoulder, wrist, or ankle.
12	17	8.1	Disabling heel damage. Loss or severe damage of several fingers. Severe lumbar problems.
15	11	5.3	Severe impairment of shoulder function, disabling lumbar problems
18	2	1.0	Severe impairment of shoulder function.
20	7	3.3	Loss of right thumb and damage to other fingers. Eye damage causing severe reduction in sight. Slight brain damage in combination with other physical damage.
25	5	2.4	Loss of sight on one eye. Fractures of spine without paralysis. Loss of three fingers and damage to the remaining two on right hand.
30	2	1.0	Lung and heart problems after exposure to toxic fumes. Severe shoulder and arm impairment.
50	2	1.0	Loss of one leg below knee.
55	2	1.0	Complications due to pelvic fracture giving severely reduced mobility. Loss of several fingers including the right thumb.
90	1	0.5	Severe physical incapacity due to burns affecting 73% of the skin.
100	1	0.5	Severe brain damage after cranial trauma.
120	1	0.5	Extensive physical and mental incapacity after fall from great height.

additional information. The master of a Danish flag ship has a statutory duty to notify the Danish Maritime Authorities of all personal injuries aboard leading to incapacity of more than 1 day beyond the day the accident took place. From time to time the authorities also receive non-mandatory notifications of accidents, but we have only included those accidents which according to Danish law were notifiable.

Accidents causing permanent disability

A second source of information was available in the Danish Shipowners' Accident Insurance Association, a mutual non-profit making insurance company. Until 1994, the Danish Shipowners' Accident Insurance Association had a monopoly as well as a statutory obligation to insure all people employed on board privately owned Danish merchant ships. After an EU Directive, the insurance market in Denmark was liberalised in 1994 but on account of its very competitive premiums, Danish Shipowners' Accident Insurance Association has retained a virtual monopoly. To insure that accidents at sea are treated in the same way as those on shore, the National Board of Industrial Injuries, a government institution, reviews all cases and determines the degree of disability as well as the loss of working capacity. To identify all accidents resulting in payment of compensation for permanent disability and fatal cases, all files of the insurance company, Danish Shipowners' Accident Insurance Association received in the period 1993–8 were reviewed. All cases where the accidents had happened in the 5 year period 1993–7 and where compensation for permanent disability had been awarded were identified. Follow up was stopped in March 2000, and at that time, a total of 209 cases of permanent injury and 27 fatal cases were identified. According to Danish law, all cases shall be closed within 2 years after the accident although some case may later be re-evaluated. At the time the study closed, decisions should have been made on all claims for accidents within the study period. Among the 236 accidents causing permanent disability or death, 187 (79.2 %) had been notified to the maritime authorities but only 174 (73.7%) had been reported as accidents causing more than one day off duty.

Time at risk

Information on employment periods has been compiled from a database established with data obtained from a register in the Danish Maritime Authority. Danish shipping companies are legally bound to fill out an employment contract form each time a seafarer is signed on, and a copy of the contract has to

Table 2 Study population, incidence of notified accidents, incidence of injuries causing payment of disability compensation, and fatal accidents by occupation (rank) of the victim on board

			All identified accidents		Accidents causing permanent injury of 5% or more*		Fatal accidents†	
Occupation	Employment periods	Days at sea	Accidents (n)	Accident rate/10000 days	Accidents (n)	Accident rate/10000 days	Accidents (n)	Accident rate/10000 days
Navigation officers	31364	2585021	182	0.70	43	0.17	7	0.027
Ship's engineers	20902	1649996	233	1.41	39	0.24	1	0.006
Ratings, deck	30878	3397492	862	2.54	81	0.24	13	0.038
Ratings, engine	6668	793473	154	1.94	14	0.18	0	0.000
Galley crew	9301	920675	161	1.75	12	0.13	4	0.043
Catering crew	20242	1436055	301	2.10	13	0.09	2	0.014
Other crew	7929	591345	100	1.69	7	0.12	0	0.000
Total	127284	11374057	1993	1.75	209	0.18	27	0.024

*Among the 209 accidents causing permanent injury, 151 (72%) had also been notified to the maritime authorities as notifiable occupational accidents; †among the 27 fatal accidents, 23 had also been notified to the maritime authorities as notifiable occupational accidents.

Table 3 Study population , incidence of notified accidents, incidence of injuries causing payment of disability compensation, and fatal accidents by type of ship

Ship type	Employment periods	Days at sea	All identified accidents		Accidents causing permanent injury of 5% or more		Fatal accidents	
			Accidents (n)	Accident rate/10000 days	Accidents (n)	Accident rate/10000 days	Accidents (n)	Accident rate/10000 days
Container ships	23223	2047939	297	1.45	17	0.08	3	0.015
Dry cargo	16607	1672118	265	1.58	30	0.18	3	0.018
Coasters	18216	2260014	317	1.40	60	0.27	10	0.044
Roll on roll off	4512	518643	148	2.85	15	0.29	2	0.039
Passenger ships	22858	1693881	446	2.63	16	0.09	1	0.006
Tankers (oil, chemical)	17046	1477657	271	1.83	31	0.21	1	0.007
Tankers, gas	7409	735089	63	0.86	10	0.14	2	0.027
Other ships	17413	968716	186	1.92	30	0.31	5	0.052
Total	127284	11374057	1993	1.75	209	0.18	27	0.024

be the sent to the Danish Maritime Authority. A similar notification has to be sent in when the seafarer signs off. Denmark has a system of personal identification numbers, which enables maintainance of such a register. Foreigners are given a personal identification number the first time they sign onto a Danish ship. After setting up the project database it was possible to exactly calculate the days worked on board for each person. For each employment period, occupation, ship's identification letters, nationality of the seafarer, and dates of start and end of employment are recorded in the register. The study includes a total of 127 284 employment periods of which 115 593 started and ended within the study period. A total of 5598 seafarers were already signed on on the first day of the study and 6 094 seafarers were signed on on the day the study ended. The employment period of one seafarer covered the whole study period, starting before and ending after the set dates. The mean duration of employment periods starting and ending within the study period was 75 days for Danish citizens

Table 4 Estimates from Poisson regression analysis of relative risk of having an notified notifiable accident not causing permanent disability of 5% or more or an accident causing permanent disability or death (different types of cargo ships only, for passenger ships see table 5)

Risk factor	Notified notifiable accidents not causing disability of 5% or more		Accidents causing permanent disability of ⩾5%	
	Cases	Adjusted* RR (95% CI)	Cases	Adjusted* RR (95% CI)
Age at time of accident (y):		(p=0.004)		(p<0.001)
< 25	223	1.00 (reference category)	17	1.00 (reference category)
25–34	401	1.18 (0.99 to 1.40)	50	1.77 (0.98 to 3.17)
35–44	363	1.22 (1.01 to 1.47)	37	1.49 (0.80 to 2.78)
45–54	242	1.02 (0.84 to 1.24)	67	3.26 (1.82 to 5.83)
⩾55	50	0.76 (0.55 to 1.04)	17	2.71 (1.32 to 5.56)
Occupation on board:		(p<0.001)		(p=0.01)
Navigation officers	131	1.00 (reference category)	43	1.00 (reference category)
Ship's engineers	171	1.96 (1.56 to 2.47)	35	1.48 (0.94 to 2.32)
Ratings, deck	720	5.42 (4.45 to 6.59)	75	2.29 (1.51 to 3.48)
Ratings, engine	96	3.52 (2.67 to 4.65)	10	1.88 (0.91 to 3.89)
Galley crew	65	1.95 (1.44 to 2.63)	12	1.14 (0.60 to 2.18)
Catering crew	35	2.14 (1.46 to 3.13)	6	1.66 (0.68 to 4.03)
Other crew members	61	3.09 (2.24 to 4.26)	7	2.09 (0.90 to 4.85)
Ship type:		(p<0.001)		(p<0.001)
Container ships	266	1.00 (reference category)	17	1.00 (reference category)
Dry cargo	222	1.24 (1.03 to 1.49)	30	2.85 (1.54 to 5.27)
Coasters	240	0.98 (0.81 to 1.18)	59	4.38 (2.49 to 7.70)
Roll on roll off	128	1.97 (1.58 to 2.45)	15	3.87 (1.89 to 7.90)
Tankers, oil, chemical	230	1.29 (1.08 to 1.55)	30	2.82 (1.54 to 5.16)
Tankers, gas	51	0.61 (0.45 to 0.83)	10	1.92 (0.87 to 4.23)
Other ships	142	1.07 (0.86 to 1.32)	27	3.32 (1.77 to 6.21)
Nationality:		(p<0.001)		(p<0.001)
Danish citizens	905	1.00 (reference category)	143	1.00 (reference category)
Foreigners	374	0.54 (0.47 to 0.63)	45	0.49 (0.33 to 0.74)
Change of ship since last employment period:		(p=0.193)		(p=0.289)
Change of ship	621	1.00 (reference category)	89	1.00 (reference category)
Same ship as last time	339	0.91 (0.79 to 1.05)	61	0.78 (0.56 to 1.10)
No information	319	0.89 (0.77 to 1.03)	38	0.80 (0.53 to 1.19)
Time aboard when accident took place (days):		(p<0.001)		(p=0.034)
1–15	232	1.00 (reference category)	42	1.00 (reference category)
16–30	176	0.87 (0.71 to 1.05)	22	0.60 (0.36 to 1.01)
31–60	344	1.01 (0.85 to 1.19	51	0.85 (0.56 to 1.28)
61–90	201	0.86 (0.71 to 1.04)	30	0.75 (0.47 to 1.21)
>90	326	0.62 (0.52 to 0.75)	43	0.51 (0.33 to 0.81)

*Adjusted for all other variables presented in the table.

Table 5 Estimates from Poisson regression analysis of relative risk of having an notified notifiable accident not causing permanent disability of 5% or more aboard passenger ships

	Notified notifiable accidents not causing disability of ⩾5%	
	Cases	Adjusted* RR (95% CI)
Age at time of accident (y):		(p<0.001)
<25	131	1.00 (reference category)
25–34	186	0.77 (0.61 to 0.96)
35–44	54	0.54 (0.38 to 0.75)
45–54	37	0.50 (0.34 to 0.74)
⩾55	11	0.50 (0.26 to 0.94)
Occupation on board:		(p<0.001)
Catering crew	249	1.00 (reference category)
Ship's engineers	17	0.93 (0.56 to 1.54)
Ratings, deck	33	1.13 (0.77 to 1.64)
Ratings, engine	44	1.54 (1.09 to 2.18)
Galley crew	73	1.84 (1.41 to 2.40)
Navigation officers	1	0.06 (0.01 to 0.44)
Other crew members	2	0.20 (0.05 to 0.79)
Nationality:		(p<0.001)
Danish citizens	382	1.00 (reference category)
Foreigners	37	0.50 (0.35 to 0.70)
Change of ship since last employment period:		(p=0.697)
Change of ship	87	1.00 (reference category)
Same ship as last time	259	0.92 (0.72 to 1.17)
No information	73	0.85 (0.62 to 1.16)
Time aboard when accident took place (days):		(p<0.001)
1–15	106	1.00 (reference category)
16–30	45	0.59 (0.42 to 0.84)
31–60	81	0.72 (0.54 to 0.96)
61–90	46	0.60 (0.43 to 0.85)
>90	141	0.62 (0.47 to 0.80)

*Adjusted for all other variables presented in the table.

and 145 days for foreigners. Only time actually spent on board within the study period is included in the calculations. When calculating time on board, the first and last day of employment were included as full days. When a seafarer goes on holiday, he is signed off. For employment periods starting before 1 January 1993, only the time after 1 January is included and for employment periods going beyond the 31 December 1997 time spent on board after that date was excluded. A total of 26 963 different people were included in the follow up, among which 11 697 (43%) were non-Danish citizens. Seafarers from the Faeroe Islands (n=653), a Danish dependent territory, are in the analysis categorised as Danish citizens. The largest group of foreigners was from the Philippines with 5011 seafarers (19% of total) and the second largest group was from Poland with 2002 seafarers (7%). The remaining 4684 seafarers were from 104 different countries.

The 127 284 employment periods were served on 684 different ships. Classification of the ships has been done by the authors with an official ships list[13] and a guide to all Danish ships.[14] A container ship was defined as a ship constructed for container transport and equipped with cell guides. A coaster was defined as a dry cargo ship below 1600 gross registerd tonnes, or if not measured in gross registered tonnes, below 3000 gross tonnes. The category "other ships" includes various different ships—such as off shore supply vessels, cattle carriers, and deep sea tug boats.

Statistics

Databases for the study were set up in EPI-Info (Centers for Disease Control, Atlanta, USA). In the analysis on risk factors, only accidents which had taken place within a recorded employment period and where the recorded ship was the same on the notification as in the employment register, was included in the analysis. Among the 1931 notified accidents, 1866 (96.8%) fulfilled this criterion but in the analysis, only the notified accidents not causing permanent disability above 5% or death were included, which reduced the number of accidents in the analysis to 1698. Among the accidents causing permanent disability, 203 out of 209 (97.1%) could be linked to a specific employment period. Adjusted relative risks were estimated by a multiplicative Poisson regression model[15] with no interaction. The variables were grouped as shown in table 4. The significance of each variable was tested by a Wald test. Furthermore, interactions between pairs of variables were tested by comparing a model including the interaction to the model without interactions using a likelihood ratio test. Significance was considered to be $p<0.05$. The statistical analysis was done with STATA software version 7 (Stata Corporation, USA).

RESULTS

Incidence of accidents

A total of 1993 accidents were included in the study among which 1931 had been notified to the maritime authorities as notifiable occupational accidents. Table 2 shows the incidence of all identified accidents, the incidence of fatal injuries, and the incidence of permanent injuries causing disability of 5% or more leading to compensation, broken down into different occupations on board. Table 3 breaks down the accidents by types of ships. The rates in the table are given in number of accidents per 10 000 days aboard. This is equivalent to 6.4 accidents/100 years aboard, 0.67 accidents causing permanent disability of 5% or more/100 years aboard, and 0.087 fatal accidents/100 years aboard. Among the 27 fatal accidents, 19 cases were directly related to a work function aboard, seven took place during off duty hours, and one was caused by a maritime disaster. Among the notified accidents, 1054 (54.6%) happened while the ship was at sea and 854 (44.2%) while the ship was in port. For the remaining 23 cases, no information was given on the position of the ship.

Risk factors for accidents

In the analysis of risk factors, the data have been divided into accidents aboard cargo ships and passenger ships. The

Table 6 Working situations at time of accidents for all notified accidents, accidents causing permanent disability and fatal accidents. All ship types included

Working situation at time of accident	Notified accidents not causing any permanent disability or death (% of total)	Accidents causing permanent disability of 5% or more (% of total)	Fatal accidents (% of total)
Work on deck:			
Clearing up and cleaning on deck and in holds	51 (2.9)	5 (2.4)	4 (15)
Handling of general stores	32 (1.8)	1 (0.5)	0
Lashing and unlashing of cargo	67 (3.8)	5 (2.4)	0
Loading and unloading cargo	118 (6.7)	15 (7.2)	3 (11)
Mooring and anchoring operations	100 (5.7)	22 (10.5)	1 (4)
Preparing the ship for a voyage	21 (1.2)	5 (2.4)	0
Opening and closing of hatches and bow ports	46 (2.6)	7 (3.3)	0
Rigging and taking in gangways and pilot ladders	39 (2.2)	5 (2.4)	2 (7)
Routine tasks on deck (controls, daily routine jobs)	51 (2.9)	6 (2.9)	1 (4)
Maintenance on deck	102 (5.8)	6 (2.9)	2 (7)
Painting including preparation for painting	27 (1.5)	6 (2.9)	0
Repair work on deck and accommodation	71 (4.0)	9 (4.3)	0
Specialised tasks on off shore vessels and tugs	30 (1.7)	3 (1.4)	2 (7)
Tank cleaning	34 (1.9)	3 (1.4)	0
Total, work on deck	789 (44.9)	98 (46.9)	15 (46)
Work in the engine room:			
Cleaning up and cleaning in the engine room	35 (2.0)	2 (1.0)	0
Handling of engine stores	17 (1.0)	2 (1.0)	0
Maintenance in the engine room	91 (5.2)	13 (6.2)	0
Repair work in the engine room	120 (6.8)	18 (8.6)	0
Work in ship's workshop	21 (1.2)	0	0
Routine tasks in engine room (alarms, controls, etc)	9 (0.5)	2 (1.0)	0
Total, work in the engine room	293 (16.7)	37 (17.7)	0
Service functions:			
Cleaning in accommodation	45 (2.6)	2 (1.0)	0
Catering work	101 (5.7)	3 (1.4	0
Galley work	110 (6.3)	2 (1.0)	0
Handling of galley stores	24 (1.4)	1 (0.5)	0
Total, service functions	280 (15.9)	8 (3.8)	0
Walking from one place to another:			
Walking in accommodation and galley	33 (1.9)	10 (4.8)	0
Walking on deck and in cargo holds	53 (3.0)	13 (6.2)	2 (7)
Walking in the engine room and repair shop	13 (0.7)	0	0
Walking on stairs in the accommodation	31 (1.8)	8 (3.8)	0
Walking on stairs and ladders on deck and in cargo holds	26 (1.5)	3 (1.4)	0
Walking on stairs and ladders in the engine room	14 (0.8)	7 (3.3)	0
Walking on gangway (to and from the ship)	12 (0.7)	3 (1.4)	2 (7)
Total, walking from one place to another	182 (10.4)	44 (21.1)	4 (14)
Other functions:			
Boat and fire drills	28 (1.6)	4 (1.9)	2 (7)
Duty on bridge	7 (0.4)	5 (2.4)	0
Transport, ashore (on duty)	7 (0.4)	1 (0.5)	1 (4)
Maritime disasters	4 (0.2)	4 (1.9)	1 (4)
Accidents while off duty ashore	71 (4.0)	2 (1.0)	4 (15)
Accidents while off duty on board	59 (3.4)	3 (1.4)	0
Violence from passengers, piracy	17 (1.0)	2 (1.0)	0
Other accidents, poorly described accidents	20 (1.1)	1 (0.5)	0
Total, other functions	213 (12.1)	22 (10.5)	8 (30)
Total	1757 (100)	209 (100)	27 (100)

adjusted risk ratios for six different risk factors for accidents aboard different types of cargo ships are shown in table 4 and for passenger ships in table 5. As there were only 15 accidents causing permanent disability of 5% or more on passenger ships, these data were not analysed separately. In the calculation of the risk related to change of ship, only seafarers with two or more employment periods could be included as no information on previous employment for those with only one employment period recorded in the study database was available. All such first employment periods of the study are included under "no information". Time on board was calculated by subtracting the day of the accident from the day the seafarer signed on. Seafarers are signed on the day they arrive on board. The first day is often used for travel and therefore gives little time for work on board.

In the analysis of notified accidents aboard cargo ships, significant "effect modification" (interactions) were found between ship type and age ($p=0.0037$), time aboard ($p=0.001$), change of ship ($p=0.0012$), nationality ($p<0.001$), and occupation ($p<0.001$). The risk associated with time aboard was broadly the same for all ship types. The only exception was tankers carrying oil or chemicals where there was a steady reduction in risk after the first month, ending with an adjusted relative risk after 3 months of 0.22 compared with the first 15 days. On board all ship types, foreigners had the lowest risk of accidents except in the category "other ships" where the risk was equal. The largest difference between accident rates of foreigners and Danes were found on tankers (oil, chemicals) where foreigners had an adjusted relative risk of 0.28 compared with Danes. It was only on roll on roll off ships that a significant association with change of ship since last employment period was found. The adjusted relative risks were 0.60 (95% CI 0.39 to 0.92) and 1.29 (95% CI 0.86 to 1.94) comparing "same ship as last time" and "no information" with "change of ship". Significant interactions were also found between occupation and nationality

(p=0.002). Foreigners of all occupations had a lower risk of accidents than Danes except for ships engineers and navigation officers, where the risk was equal.

In the analysis of the accidents causing permanent disability of 5% or higher on cargo ships, significant interactions were found between ship type, nationality (p=0.0026), and occupation (p=0.0019) and between age and occupation (p=0.009).

Activities causing accidents

In table 6, all accidents have been classified based on the activity of the victim at the time of the accident. Accidents classified under walking on deck and stairs are defined as accidents where the victim was on his way from one task to another. If a seafarer had an accident while moving on horizontal surfaces or stairs, and this was part of another well defined task, the accident was classified under the main task.

DISCUSSION

The study indicates that not all accidents, which according to law should be reported, actually are reported; a well known phenomenon in shore based industries as well.[17] Among the accidents causing permanent injury and payment of compensation or death, one in five had not been reported to the maritime authorities. From the files we noted that despite the accident, some of the victims stayed on board and to some extent performed duties. Thus it could be argued that as some of these cases did not fulfil the statutory criterion for notification—that is, one day off work beyond the day of the accident—not necessarily all of these accidents were notifiable accidents

We would also suggest that underreporting can be found in other areas, especially when looking at the relation between accidents causing permanent disability and the number of notified accidents in the different types of ships. Coaster crews have a low rate of reported accidents yet they have the highest rate of accidents leading to permanent disability. It may well be possible that coastal shipping companies have a different safety culture than that of a deep sea liner company operating mainly container ships. The denominator data, time at risk, seems to be reliable as almost all accidents actually could be allocated to a specific employment period in a register running independently of the notification systems for accidents.

The accident rates in this study are higher than in a Polish study covering the period 1990–5[17] although the two studies are not fully comparable. The accident rates of this study are not directly comparable with rates from other, shore based industries in Denmark. A comparison could only be made if it is assumed that Danish seafarers spend roughly half of the time on board and half of the time ashore. The rate for notified accidents may then be estimated to be 3.1 notified accidents per 100 seafarers/year and for accidents causing permanent disability of 5% or more, the figure is 0.34 incidents/100 employed seafarers/year. The corresponding figures for all shore based industries in Denmark are 1.8 and 0.22/100 workers[18] and are thus considerably lower. During the study period, the rate for fatal accidents aboard was 0.044/100 employed seafarers/year whereas the corresponding figure ashore was 0.0026/100 in the workforce/year.[19]

In this study, seafarers who were Danish citizens, had a considerably higher rate of notified accidents than foreigners as well as a higher rate of accidents causing permanent disability of 5% or above. Foreigners may indeed have fewer accidents due to a different behaviour. The difference could represent a genuine difference in behaviour causing differences in the accident rates among different cultures in the same workplace. A higher rate of underreporting among this group may also be a possible explanation. Among Danish citizens, most of the serious accidents leading to permanent injury are likely to have been notified. The national social security programme will persuade all victims of occupational accidents to notify the the authorities, as an occupational accident entitles the worker to some benefits not available for non-occupational accidents or diseases. Foreigners may lack knowledge of their legal rights and at the same time might have problems in dealing with the authorities in a foreign country.

The significant effect modification found between ship type and nationality was caused by variation in the magnitude of difference between Danes and foreigners on different ship types but as Danes had the highest rates on all ship types except one, where the rate was equal, the overall conclusion is valid.

For the notified accidents, effect modification was found between ship type and all other risk factors included in the analysis. Also the analysis of accidents causing permanent disability showed effect modification to a lesser degree. The risk factors included in the analysis thus have different importance on different ship types. Besides possible differences in undernotification especially from certain ship types and the presence of effect modification between ship type and all other risk factors, the differences found between different ship types may partly be explained by major differences in level of activity rather than genuine differences in risks. Roll on roll off ships have a high risk of both types of accidents, but these ships mainly are used on very short voyages and therefore have many arrivals and departures a week and sometimes a day. This will inevitably give a high rate of accidents during mooring operations and cargo handling compared with for example bulk ships which are often doing journeys of a month or more. Specifically, the differences in the serious accidents causing permanent disability may also be explained by different tasks aboard different ship types. On roll on roll off ships, coasters, and the category other ships, the crew are often involved in cargo handling and lashing of cargo which will add to the number of accidents on these ships.

Not surprisingly, the occupation of the seafarer is an indicator of risk of accidents although the same occupation had marked differences in risk on different ship types. Deck crew involved in heavy work on deck and in holds have the highest risk of being involved in an accident. Marine engineers also have a high number of accidents but these are generally less severe than the accidents of the deck crew. Galley and catering crew have many accidents while preparing food and serving it. Such an accident will in many cases make them temporarily unfit for food handling, but the accidents seldom cause a permanent disability. The effect modification found between occupation and nationality is, however, difficult to explain.

Age of the victim has little influence on the risk of notified accidents on cargo ships, but the risk of an accident causing permanent disability increased steeply with age. The risk of permanent consequences after an accident thus increased with age. This may possibly have a simple biological explanation. The young have a good chance of complete healing of fractures and sprains. With age, the body has less capacity to regenerate and damage is more likely to be permanent. On passenger ships, the decreasing risk of accidents with age may be explained by change of function from more manually orientated towards managerial functions in the catering department and galley.

By analysing the information on which ship each seafarer was employed during a particular employment period, it is possible to evaluate the effect of changing ship. The results show a clear negative effect. Seafarers, who return to the same ship, have an overall lower risk of having an accident during the second or following employment period on the same ship. This matches the finding that the risk of an accident decreases during the employment period. This study cannot give an explanation for this result, but it is likely that familiarity with the ship improves occupational safety. It seems as if it is an advantage to have stable crews coming back to the same ship after a period of leave.

Main messages

- Accident rates differ considerably between different ship types. Crew aboard small general cargo ships (coasters) and roll on roll off ships have the highest risk of serious accidents.
- Reported accident rates among seafarers not coming from the flag state were far below the rates among seafarers from the flag state. This could represent a genuine difference in behaviour causing different accident rates among different cultures in the same workplace.
- Familiarity with the workplace seems to reduce accident rates.
- Walking on the ship from one task to another was identified as a major cause of serious accidents.

Policy implications

- Preventive interventions should especially focus on coasters and roll on roll off ships.
- Special focus on the notification of accidents among seafarers not coming from the flag state of the ship is needed to ensure their rights in case of an accident.
- Stable crews returning to the same ship after shore leave may reduce accident rates.
- Programmes on preventing accidents at sea should focus not only on certain high risk tasks like mooring operations and repair work in engine rooms but also on the high risk related to walking from one task to another.

Splitting up the activities at the time of the accident gives information on what activities are likely to cause accidents and thus indicates what preventive measures could be focused on. Working on deck made up almost half of all notified accidents, half of the accidents causing permanent disability, and half of the fatal accidents. Mooring operations have a high proportion of accidents causing permanent disability. The use of mooring winches, where the seafarer can avoid having a direct contact with the mooring ropes, are likely to reduce these serious accidents. Cargo handling, lashing work, opening and closing of hatches, and other work on deck were jobs causing a high proportion of serious accidents and are other areas for preventive measures. Most tasks causing accidents are routine work often performed aboard.

Moving around on a ship is a well known high risk activity.[20 21] It is noteworthy that these accidents made up only about 10% of the notified accidents but more than one fifth of the accidents causing permanent disability. The accidents occurred equally on ladders and stairs and on horizontal surfaces. Preventive measures may be directed towards improving footwear and indicating dangerous places aboard the individual ship. But the prevention of many of these accidents will have to start before the ship is constructed.

Risk assessments in the workplace followed up by guidelines (workplace instructions) for all routine functions aboard have so far only been used to a limited extend aboard ships, with the recently commissioned formal safety assessment study into bulk carriers being a notable exception. The concept was introduced in shore based industries in the European Union countries more than 10 years ago[22] and it may be an important instrument in preventing accidents on board ships. It can be seen as an integrated part of the implementation of the international safety management code.[23]

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